Electrical Engineering

Doctor of Philosophy (Ph.D.) Programs

Electrical Engineering is a fast changing profession and there are rapid advances in research and development of different specialization of electro technology. To cope with such advancements, some electrical engineers usually need a much higher level of education and training. The Ph.D. program was initiated in the Electrical Engineering Department in 1412H (1991G). This program responds to the needs of national research and development centers for highly qualified specialists in electrical engineering capable of effective contributions to complex scientific and technical projects.

A good deal of the scientific thesis work of graduate students deals with advanced research, development and application problems in various fields of electrical engineering. The Department has directed its research abilities so as to benefit from the rapid advances in all fields in electrical engineering to match the needs and requirements of the development plans of the Kingdom of Saudi Arabia. The Ph.D. program offers challenging opportunities for advanced research in electrical systems in the following specialization:

- Electronics
- Electromagnetic Waves and Communication
- Electrical Machines and Power Electronics
- Electrical Power and High Voltage Systems
- Computer and Control.

Degree Requirements

The Ph.D. degree requirements are:

- Completing 18 credit hours of course work from the approved Post Graduate (Ph.D.) Courses.
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    - Passing the Ph.D. qualifying comprehensive exam.
    - Satisfactory completion of the Ph.D. thesis. The student can register in the Ph.D. thesis only after he passes the qualifying comprehensive examination. He also has to meet residency requirements.

Ph.D. Courses

The available PhD courses, in different specializations, are given in the following. In selecting courses, there are certain rules that must be fulfilled.

Electronics

EE 610 Semiconductor Characterization Techniques

EE 611 Semiconductor Device Modelling

EE 612 Design and Technology of Solar Cells

EE 613 Design and Application of Photovoltaic Systems

EE 614 MOS Devices for Advanced VLSI

EE 615 Analysis and Design of VLSI Circuits

EE 616 VLSI Layout and Processing

EE 617 Layout Design of Bipolar Integrated Circuits

EE 618 VLSI for Fast Processing Systems

EE 619 Advanced Topics in Electronics

Communications

EE 620 Signal Detection and Estimation

EE 621 Channel Coding Theorem

EE 622 Advanced Digital Communications

EE 623 Digital Signal Processing

EE 624 Antenna Theory and Design

EE 625 Propagation of Electromagnetic Waves

EE 626 Secure Communication Systems

EE 627 Advanced Network Planning and Tele-traffic Engineering

EE 628 Radar Systems

EE 629 Advanced Topics in Communications

Electrical Machines and Power Electronics

EE 630 Advanced Theory of Electro-Mechanical Energy Conversion
EE 631 Computer Aided Analysis of Electrical Machines
EE 632 Special Types of Electrical Machinery
EE 633 Computational Methods in Electromagnetics
EE 634 New Concepts in Electric Machine Design
EE 635 Voltage and Frequency Converter Systems
EE 636 Special Drives and Reactive Power Control
EE 637 Advanced Topics in Drives & Power Electronics
EE638 Linear Electric Machines

Electrical Power

EE 640 Large Scale System Analysis
EE 641 Stability of Large Power Systems
EE 642 Power System Operation and Security
EE 643 Optimal Power System Planning
EE 644 Reliability Evaluation of Power System
EE 645 Electromagnetic Transients in Power System
EE 646 Advanced Power System Protection
EE 647 High Voltage Insulation
EE 648 Corona and Field Effects of High Voltage Systems
EE 649 Advances in Power System

Control Systems and Computers

EE 650 Artificial Intelligence in Engineering
EE 651 Parallel Processing and Programming
EE 652 Computer Network Protocols
EE 653 Computer Vision and Image Processing
EE 654 Microprocessor Based Instrumentation & Control
EE 655 Digital Control Systems
EE 656 Non-linear Control Systems
EE 657 Stochastic Control Systems
EE 658 Adaptive and Learning Control Systems
EE 659 Advanced Topics in Computer & Control

Seminar Courses and Thesis

EE 661 Seminar (1)
EE 662 Seminar (2)
EE 663 Seminar (3)
EE 700 Ph.D. Research

Ph.D. Courses

EE 610 - Semiconductor Characterization Techniques (3 credit hours)

Bulk, surface and interface parameters - electrical methods (resistivity, lifetime, mobility dopant, profile, ...) - physical methods (optical microscopy, TEM, SEM, X-ray topography, ellipsometry, ...). Chemical methods (NAA, mass spectroscopy, emission spectroscopy, X-ray fluorescence, ion-microprobe, electron microprobe, photo-luminescence, infrared spectroscopy).

EE 611 - Semiconductor Device Modeling (3 credit hours)

Fundamental properties; Process modeling (ion implantation, diffusion & oxidation); Physical parameters (mobility, generation and recombination rates, conductivity, ...); Analytical investigations; Basic semiconductor equations; Discretization of basic equations; Solution of system of non-linear algebraic equations, solution of sparse system of linear equations; A case study.

EE 612 - Design and Technology of Solar Cells (3 credit hours)

Standard silicon solar cell technology: raw material to single crystal silicon; Improved silicon cell technology: solar grade silicon; silicon sheet; cell fabrication; Design of silicon solar cells: major considerations; doping of substrate; back surface fields; top layer limitation; top contact design; optical design; Spectral response. Other device structures: homojunctions; hetrojunctions; MS, MIS, ... Other semiconductor materials.

EE 613 - Design and Applications of Photovoltaic Systems (3 credit hours)

Components of a photovoltaic system: introduction; PV modules (construction, I-V characteristic, performance); Energy storage (batteries for PV use, performance); power conditioning - Design of stand-alone PV systems: introduction; system sizing - Applications of stand-alone PV systems. Residential and centralized PV power systems.

EE 614 - MOS Devices for Advanced VLSI (3 credit hours)

Review of semiconductor surface properties; Submicron MOS device physics and models; Reliability and failure models for submicron devices. Submicron MOS device applications.

EE 615 - Analysis and Design of VLSI Circuits (3 credit hours)

CMOS operational amplifiers; Micropower techniques; Dynamic analog techniques; NMOS operational amplifiers; Switched-capacitor filter synthesis; Performance limitations in switched-capacitor filters; Continuous - time filters; Nonlinear analog MOS circuits.

EE 616 - VLSI Layout and Processing (3 credit hours)

Introduction to VLSI design concepts; Layout design approaches (full custom, semicustom and gate array); Symbolic layout; CAD tools for layout generation; Simulation tools; Impact of processing on design rules; Processing techniques (film deposition, oxidation, diffusion, lithography, ...); yield and reliability; typical NMOS and CMOS design projects.

EE 617 - Layout Design of Bipolar Integrated Circuits (3 credit hours)

Analysis and design of bipolar circuit components. Analysis and design of bipolar operational amplifier and more complex analog circuits. Analysis and design of bipolar logic gates and more complicated logic functions. Layout of bipolar ICs. Fabrication processes and technology.

EE 618 - VLSI for Fast Processing Systems (3 credit hours)

Programming concurrent machines; Developing the hardware support for this style of programming; Construct concurrent data structures, Data flow and communication through the array of processors; Analysis of large data system (case study).

EE 619 - Advanced Topics in Electronics (3 credit hours)

Designed to cover the latest achievements in electronics-based research topics.

EE 620 - Signal detection and estimation (3 credit hours)

Hypothesis testing, Sequential detection, Estimation theory, Maximum likelihood and Bayes methods, Estimation of signal parameters and continuous waveforms, Wiener and Kalmn filtering, Application to the design of optimum receivers adaptation system.

Co-requisite EE 502

EE 621 - Channel Coding Theory (3 credit hours)

Mathematical preliminaries: groups, rings and fields, Linear block codes: syndrome and error detection and correction, minimum distance, error-detection and error-correction capabilities, Galois field: construction and arithmetic, cyclic codes and their circuit implementation, binary and non-binary BCH codes and their decoding. Burst error-correcting codes convolutional codes, Decoding of convolutional codes: Vetechi algorithm, sequential and majority-logic decoding, Performance of error control codes: weight distribution, bounds on minimum distance of block and convolutional codes.

EE 622 - Advanced Digital Communications (3 credit hours)

Synchronization: Receiver synchronization, network, synchronization. Equalization and diversity techniques. Hybrid modulation and coding techniques. Multiplexing and multiple access: FDM/FDMA, TDM/TDMA, CDMA, Access algorithms.

Co-requisite EE 502

EE 623 - Advanced Digital Signal Processing (3 credit hours)

Review of discrete-time stochastic processes; Linear prediction theory; least-squares methods for systems modeling and filter design; Adaptive filters; Spectral analysis; applications.

Co-requisite EE 525

EE 624 - Antenna Theory and Design (3 credit hours)

Frequency independent antennas, Horn antennas and slot radiations, Microstrip antennas, Aperture antennas, Reflector and lens antennas, Phased arrays.

Co-requisite EE 521

EE 625 - Propagation of Electromagnetic Waves (3 credit hours)

Transmission and reception of radio waves in the presence of earth and its atmospheric, Ionospheric propagation, Tropospheric propagation, Atmospheric effects on terrestrial and space propagation.

Co-requisite EE 521

EE 626 - Secure Communication Systems (3 credit Hours)

Modulation and coding, Direct sequence spread-spectrum systems, Frequency hopping, Interception, Adaptive antenna systems, Cryptographic communications.

Co-requisite EE 502

EE 627 - Advanced Network Planning and Teletraffic Engineering (3 credit hours)

Structure of telephone networks, Analysis of demands and services, Forecasting and technology considerations, Teletraffic models, Analysis of network capacity, Development of computer tools, Applications and case-studies.

EE 628 - Radar Systems (3 credit hours)

The radar equation, CW and frequency-modulated radar, MTI and pulse-doppler radar, Tracking radar, Radar detection, Radar clutter, System design.

Co-requisite EE 502

EE 629 - Advanced Topics in Communications (3 credit hours)

EE 630 - Advanced Theory of Electro-Mechanical Energy Conversion (3 credit hours)

Basic coordinates, lumped elements, and energy-state functions. Equilibrium equations from energy-state functions: (LAGRANGE'S equation). Formulation of equilibrium equations for electro-mechanical systems. Analysis of linear systems. Response characteristics of electro-mechanical systems.

EE 631 - Computer Aided Analysis of Electrical Machines (3 credit hours)

Machine Models: Phase and primitive equivalent circuit representations. Advanced hybrid field models and permanent magnets. Models for Control Systems: d.c. and synchronous machines speed control, S.C.R. models and voltage control. Nonlinearities in Electric Machine: magnetic saturation, friction, etc. Solution Method: Steady state and transients states; methods based upon numerical integrations, non-linear equations, polynomial equations. Applications: Alternators, induction motors & generators, stepper motors and reluctance machines, S.C.R. fed d.c. drives.

EE 632 - Special types of Electrical Machinery (3 credit hours)

Linear machines (induction - synchronous ... etc.). Stepper motors (PM, VR & Hybrid). Special modes of operation of I.M. (electro-magnetic brakes - Induction generator). Self synchronous systems (Selsyns). Permanent Magnet Machines.

EE 633 - Computational Methods in Electromagnetics (3 credit hours)

Analytical requirements and boundary conditions in electromagnetic field problems. Analytical and numerical methods such as finite difference, finite element, geometrical theory of diffraction, moment method, Monte Carlo and charge simulation method, etc. Applications of electromagnetic field problems in electrical machines.

EE 634 - New Concepts in Electric Machine Design (3 credit hours)

Modelling of the machine; field relations, departures from the ideal model, determination of lumped network parameters and external constraints. Mechanical stress limitations: Maximum speed, stresses in rotor wedges and teeth, stresses in shafts and length of air-gap. Magnetic loading: Magnetic structure, magnetizing current and optimal choice of flux density. Thermal stress limitation: internal air ventilation, liquid cooling, heat pipes, transient heating and allowable temperature rise. Electric loading: Thermal relations and performance relations. No-load losses: losses in teeth and cores. Additional losses due to skin effect and harmonics. Surface losses and flux pulsation losses. Copper losses: additional losses due to skin effect and harmonics. Calculation of resistances and inductances. Basic design and scaling laws.

EE 635 - Voltage and Frequency Converter Systems (3 credit hours)

Rectifier and Chopper circuits, analysis, simulation and control strategies application to DC motor drives. Frequency Control: Inverters (voltages, current and resonant types), Cycloconverters and frequency changes: Circuitry, simulation, analysis, and control strategies. Applications to induction motors and, Static Control Power Supplies.

EE 636 - Special Drives and Reactive Power Control (3 credit hours)

Advanced Techniques for special motors control; Stepper motors, Permanent magnet motors (PM) and switched reluctance motors. Static controlled power supplies: UPS systems and switched mode power supplies. Reactive power control: Switched capacitor banks, FC-TCR system and current sources and voltage source Var generators. Harmonic control.

EE 637 - Advanced Topics in Drives and Power Electronics (3 credit hours)

The course is designed to cover some of the latest developed devices, systems and techniques.

EE 638 - Linear Electric Machines (3 credit hours)

Concepts of linear electrical machines. types: Linear and tubular induction motors; Linear stepper motors; Linear dc machines. Applications: Metal handling; Traction; Conveyor systems. Analysis of linear machines: Direct solution; Fourier method; Finite element method; Two and three dimensional solutions and boundary element analysis. Design aspects.

EE 640 - Large Scale Systems Analysis (3 credit hours)

Modeling techniques. Equivalence: coherency, singular perturbation, decomposition, selective modal analysis. Centralized and decentralized controllers for power system control centers.

EE 641 - Stability of Large Power Systems (3 credit hours)

Concept of direct methods and energy function. Steady state stability evaluation, sensitivity analysis. Interconnection of power pools. Impact of interfacing between AC/DC on system performance.

EE 642 - Power System Operation and Security (3 credit hours)

Unit commitment, Hydro-thermal coordination, Pools and superpools dispatching. Automatic generation control. Security analysis. Reactive power control. Optimization methods in power system.

EE 643 - Optimal Power System Planning (3 credit hours)

Forecasting methods for electric loads and energy. Environmental effects. Decision-making processes based on economic and reliability considerations. Characteristics and modelling techniques of alternative power plants. Global planning.

EE 644 - Reliability Evaluation of Power System (3 credit hours)

Static and operating reserve. Interconnected power systems reliability evaluation. Production costing methodologies. Power outages impact and cost estimation. Case studies: data acquisition and simulation.

EE 645 - Electromagnetic Transients in Power System (3 credit hours)

Origin, types and effect of electromagnetic transients. Effect of frequency on transmission lines and cables parameters. Digital models of power system components.

EE 646 - Advanced Power System Protection (3 credit hours)

The nature of relay input signals immediately after a fault occurrence. Transient response of current transformers and potential transformers. Modelling of system and transducers induced noise signals. Optimal estimation of impedance from noisy input signals. Extended linear and non-linear Kalman filtering techniques. Microprocessor-based distance relaying systems. Traveling-wave relays; discriminants, auto-correlation of signals. Multi-microprocessor-based traveling-wave relaying systems.

EE 647 - High Voltage Insulation (3 credit hours)

Characteristics, failure mechanisms and applications of solid liquid, Gaseous, vacuum and composite insulating materials. Life estimation of insulation systems. Insulation coordination. Critical stress values for commonly used insulation media.

EE 648 - Corona and Field Effects of High Voltage Systems (3 credit hours)

Calculation of electric fields for transmission lines. Corona modes and its energy contents. Weather effects on corona. Undesirable effects of corona (RI, TVI, AN, Corona loss). Electromagnetic and electrostatic inductions. Biological effects of HV systems. HV system design consideration.

EE 649 - Advanced Topics in Power System (3 credit hours)

EE 650 - Artificial Intelligence in Engineering (3 credit hours)

Foundation of the theory of artificial intelligence. Game playing, pattern recognition, description of cognitive processes. Heuristic decision procedures. General problem solvers. Learning systems and robotics.

EE 651 - Parallel Processing and Programming (3 credit hours)

Computer architectural classification schemes. Pipelining and vector processing. Array processor. Multiprocessor architecture. Sequential versus parallel . Parallel programming structure. Occam programming. Practical case-studies.

EE 652 - Computer Network Protocols (3 credit hours)

Computer network architecture and the layers ISD, OSI protocols. The physical layer protocols. The data link layer protocols. The network-layer, transport-layer and session-layer protocols. The presentation-layer protocols. The application-layer protocols. Standard recommendations and protocols.

EE 653 - Computer Vision and Image Processing (3 credit hours)

Introduction to image processing. Digitization and processing of gray scale images. Segmentation, thinning and contour following. Curve fitting and curve approximations. Digital shape analysis.

EE 654 - Microprocessor Based Instrumentation & Control (3 credit hours)

Advanced microprocessor interfacing techniques. Data conversion, Signal processing, Applications to instrumentation and control, some case studies.

EE 655 - Digital Control Systems (3 credit hours)

Introduction to digital control systems, Z transform, signal sampling and reconstruction. Open-loop and closed loop discrete time systems. State variable models. Time-response characteristics. Stability analysis techniques. Digital controller design.

EE 656 - Non-linear Control Systems (3 credit hours)

General conceptions of non-linear design. Common physical nonlinearities, phase-plane analysis and trajectory classification. Describing functions. Time domain analysis. Non-linear system stability. Synthesis of non-linear control systems.

EE 657 - Stochastic Control Systems (3 credit hours)

Description of Stochastic processes. Time domain and frequency domain analysis of filtering, smoothing and prediction problems. Kalman filtering and Riccati equation. Control of Markov process and discrete linear systems using dynamic programming, Linearing control of stochastic processes.

EE 658 - Adaptive and Learning Control Systems (3 credit hours)

Introduction to system uncertainties. System identification techniques. Adaptive control problems. Techniques of adaptive control and self-tuning control. Variable-structure systems. Supervised and Non-supervised learning control. Introduction to robotics.

EE 659 - Advanced Topics in Computer & Control (3 credit hours)

Advanced topics in computer and control.

EE 661 - Seminar (1) (2 credit hours)

EE 662 - Seminar (2)

EE 663 - Seminar (3) (2 credit hours)

EE 700 - Ph.D. Research